CPS: Medium: Integrating sensors, controls, and ecotoxicology with decoupled aquaponics using brackish groundwater and desalination concentrate for sustainable food production.

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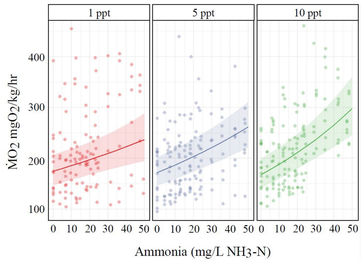
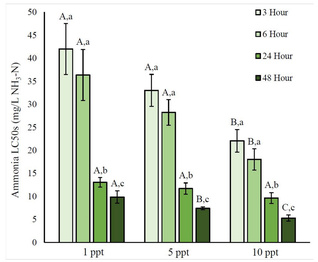
Challenge:

- Demonstrate that brackish groundwater desalination costs can be offset by using its byproducts for profitable food production.
- Separating nutrients from Recirculating Aquaculture System (RAS) allows to improve its water quality and use nutrient-rich water for hydroponics where it is needed.
- Develop an early alert system to detect and correct toxic stress conditions affecting the aquaculture organisms, thus optimizing growth and survival.



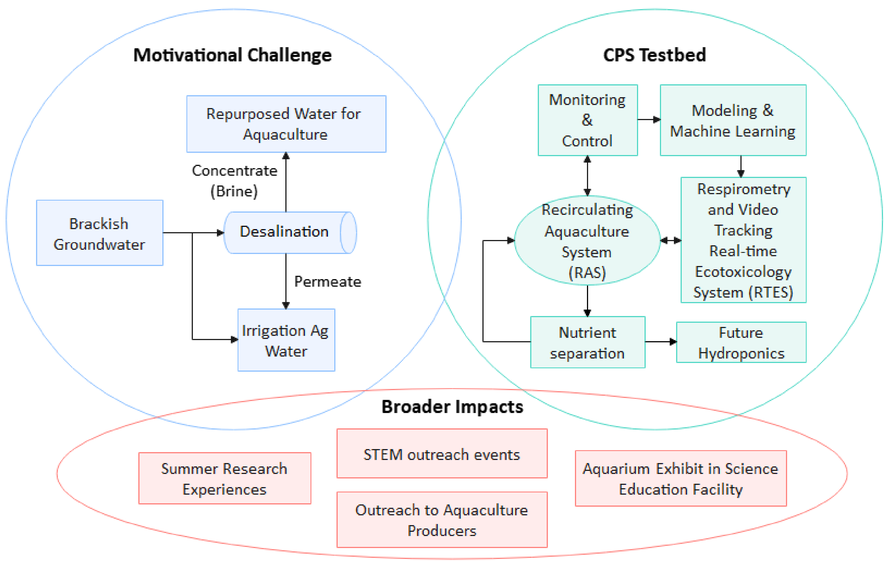
Metabolic Rate by Respirometry



LC-50 Toxicity Bioassays

Emadi C., Neto F., et al. 2024. Effects of Salinity on the Toxicity and Real-Time Metabolic Rate Responses of Acute Ammonia Exposure to Juvenile *Macrobrachium rosenbergii*. Poster presentation at Society of Environmental Toxicology and Chemistry. Fort Worth, TX.

Giant River Prawn
(*Macrobrachium rosenbergii*)

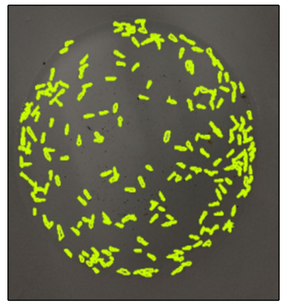


Three RAS installed in the lab with the Giant River Prawn

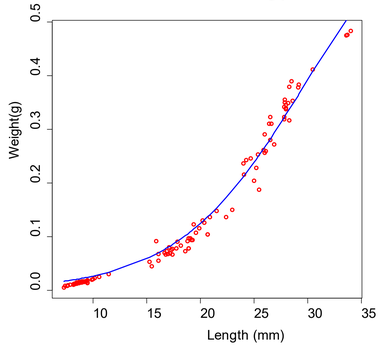
Gasperin A, Padilla C., and Roloff, J. 2023. Water Quality Monitoring System for Crustacean Based Aquaponics. EE Senior Design Project.

Scientific Impact:

- A substantial innovation of this research is the development of real-time respirometry, which has *value beyond* the specifics of this project.
- Combined with video tracking for behavioral assessment of toxicity into a Real-time Ecotoxicology System (RTES), powered by AI, is a *unique contribution* of this research.
- Consolidating all variables in AI to assist in developing models useful to design and operate production-scale systems, represents an *advance in CPS technology*.



Output labeled image



Model (Weight vs. Length)

Neto, F., Dang, T.H., et al. 2024, Image Recognition Model for Crustacean Postlarvae Counting and Size Estimation. Poster presentation at Texas Chapter of the American Fisheries Society Annual Meeting. College Station, TX

Solution:

- Advancing real-time monitoring and control, aided by data analysis and machine learning, to optimize RAS operating conditions.
- Implementing desalination system for nutrient distribution between RAS and a future hydroponics loop (HP).
- Developing a real-time ecotoxicology system by integrated respirometry and behavioral assessment (via video tracking and machine learning) and apply it to the RAS
- Modeling organism growth and survival linked with nutrient distribution and water quality dynamics.
- Integrating all systems into a CPS testbed that includes networking, computing, and opportunities for education and outreach.

Broader Impact, Societal Benefits:

- Demonstrate that it is possible to repurpose desalination byproducts to produce food, offsetting the costs of treatment, while reducing environmental impacts from those byproducts.
- Benefits populations in many areas with semi-arid and arid climate, brackish groundwater, and scarcity of surface water, as well as saline aquaculture producers worldwide.

Broader Impact, Education and Outreach:

- Developing an exhibit and activity emphasizing interdisciplinary CPS research conducted during the academic year.
- Offering summer research experiences to students.
- Participating in STEM outreach events to promote interdisciplinary CPS research.

Broader Impact, Quantification of impacts:

- Economic impacts will be quantified by life-cycle cost-benefit analysis of the integrated water and food production, including costs of treated water and concentrate disposal, market price of shrimp, and revenues.
- This analysis will indicate the feasibility of recovering the desalination concentrate for profitable food production as well as using water efficiently for multiple purposes.

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